The diabetics examined showed, as was to be expected, an initial hyperglycæmia, with 60 per cent. of the cases giving a type 2 curve.

In the cases of thrombo-angiitis the initial figures were practically normal and the type of reaction in 75 per cent. of the cases was that of type 2.

In pregnancy there is also an initial hyperglycæmia, and 66 per cent of the cases gave a type 1 reaction. Pyogenic infections gave 70 per cent. type 2 reaction.

In degenerative tissue conditions, such as cirrhosis of the liver, myocarditis, etc., one case was observed with a blood sugar concentration of 239 mg. without urinary leakage.

As we have stated before, our original paper had to do with the reaction in cases of cancer. Our present report necessitates a very considerable modification of our previous statements. In that paper we considered what we have since termed type 1 to be a possibly specific reaction in cancer.

In our series of benign tumors we have found 31 per cent. to give type 1 reaction as compared with 56 per cent. of epitheliomata, 61 per cent. of gastric carcinomata, 50 per cent. of intestinal carcinomata, 30 per cent. of breast carcinomata, 20 per cent. of genital organ carcinomata and 66 per cent. of other non-grouped malignant tumors. The actual number of cases is given in Table III. Initial hyperglycæmia occurs in some instances, but is not constant. The fact that so high a percentage of type 1 reaction occurred with epitheliomata not showing cachexia renders untenable the theory that the high percentage given by gastric carcinomata is due to cachexia and the demand of the tissues for sugar.

Conclusions. It is evident, from the data here presented, that the organism may respond in one of three ways after the ingestion of 100 gm. of glucose. Neither of these three reaction types can be considered as diagnostic of any given pathological condition, though, in general, conditions associated with increased growth energy show a higher percentage of type 1 reaction. There is no fixed type of reaction even in metabolic disturbances, absolutely similar curves being found in conditions as widely different as diabetes, tuberculosis, epithelioma and pregnancy. Many diseased conditions are accompanied by hyperglycæmia. The concentration of blood sugar is not the sole factor concerned in the development of glycosuria.

THE GERMICIDAL VALUE OF POTASSIUM MERCURIC IODIDE.

By Douglas Macfarlan, M.D.,

Since the second year of the war the subject of antisepsis has acquired a new interest and need has arisen to refresh and revise

our knowledge of the relative merits and faults of various germicides. In former times personal preferences, based largely on empiricism, led to the choice of this or that chemical substance for the purpose of disinfecting operative sites and wounds. Oftentimes certain collateral qualities of the germicides, such as solubility, reputed lack of toxicity and so forth, rather than their actual killing power on bacteria under surgical conditions, were emphasized.

Any comparison of germicides should be based (1) on their bactericidal efficiency and (2) on their physical and chemical properties. For some time past the writer, realizing the disadvantages of many of the germicides in general use, has devoted himself to the study of potassium mercuric iodide.

Earlier experiments already reported[1] have demonstrated several marked advantages of this substance over other iodin and mercury salts in addition to its value in the treatment of infectious conditions,[2] [3] [4]. Watson[5] and Hinman[6] obtained fresh evidence of its high germicidal potency, while Rosenberger,[7] working with an analogous compound, confirmed the efficiency of this type of mercury salt.

Potassium mercuric iodide is a distinct chemical entity, formed by the direct combination of two molecules of potassium iodide with one molecule of mercuric iodide, and has the formula K_2HgI_4 or $HgI_2 2KI$. For this reaction, and also in order that the subsequent conversion of this double salt into the red iodide of mercury may be prevented, an excess of potassium iodide is necessary. In the crystalline state the salt is deliquescent, and upon taking up water, readily deposits the red mercuric iodide. It may, however, be obtained in tablet form, in which the two salts (mercuric iodide and potassium iodide) are bound by an inert soluble excipient and readily yield clear, stable solutions of the double salt. This is by far the most convenient form in which to obtain and employ this substance.

Before considering the high germicidal potency of potassium mercuric iodide four distinctive and valuable features making for its superiority over other salts of mercury and iodin may well be considered.

[1] Macfarlan, Douglas: Notes in the Study of Potassium Mercuric Iodide, Jour. Am. Med. Assn., January 3, 1914, lxii, 17–19.

[2] Macfarlan, Douglas: Still Another Suggestion for Atrophic Rhinitis; the Double Iodide of Mercury and Potassium, Jour. Ophthl., Otol. and Laryng., October, 1913, vol. xix.

[3] Macfarlan, Douglas: A Rationale of a New Treatment for the Acute Frontal Sinusitis, Jour. Ophth., Otol. and Laryng., September, 1915, vol. xxi.

[4] Macfarlan, Douglas: A Consideration of Pyorrhea and the Rationale of a New Remedy, with Case Reports, Jour. Ophth., Otol. and Laryng., November, 1916, vol. xxii.

[5] An Improved Substitute for Iodized Catgut Sutures, Surg., Gynec. and Obst., January, 1916, xxii, 114–115.

[6] Urinary Antiseptics, Jour. Am. Med. Assn., November 20, 1915, lxv, 1769.

[7] On Lithio Mercuric Iodide, Am. Med., June 25, 1904, vii, 1021.

1. *Solubility.* It is readily soluble in both water and alcohol as well as in acetone.

2. *Toxicity.* As compared with the most prominent metallic germicide—mercuric chloride—it is far less toxic, and, in dilutions effective for germicidal use, the factor of safety renders it comparatively harmless for irrigations of mucous membranes or for any purpose in which there is a likelihood of its being swallowed. Even a 1 per cent. solution may be taken internally in doses of six to eight drops without producing gastric irritability, while one would have to swallow about 30 c.c. of the 1 to 1000 solution or 300 c.c. of the 1 to 10,000 solution to obtain the maximum medicinal dose.

3. *Lack of Irritation.* One-half of 1 per cent. solutions are slightly irritating to the mucous membranes, causing a burning sensation with the stimulation of a watery secretion. Solutions of these strengths have little or no irritating effect on the skin when applied for twenty-four hours by a wet pack or compress, while dilutions of 1 to 1000 or more cause none of the disagreeable effects upon the hands produced by similar solutions of bichloride of mercury.

4. *Non-precipitation of Proteins.* Contrary to the action of other metallic germicides in the presence of proteins, potassium mercuric iodide fails to precipitate these substances. Experiments by the author have shown that so soluble is this salt in protein solutions that human blood serum readily dissolves 100 per cent. of potassium mercuric iodide without any appreciable coagulation or precipitation of the serum albumin or globulins. This lack of affinity for serum proteins is an important factor in those cases in which it is desired to achieve potent germicidal action in the presence of blood, pus or other tissues. That the germicidal action of the double salt, unlike other antiseptics and germicides, is only slightly diminished by the presence of organic matter will be shown in Table VII.

GERMICIDAL ACTION. Potassium mercuric iodide has long been known as a potent germicide, exerting not only an antiseptic but a true killing power in high dilutions. In the well-known table of Park[8] the red iodide of mercury, the active component of the double salt, stands at the head of the list for potency. Earlier experiments by the author, reported in 1914,[1] showed that potassium mercuric iodide in a dilution of 1 to 80,000 killed such organisms as Bacillus typhosus, Staphylococcus aureus, Bacillus bulgaricus, Bacillus acidi lactici and a yeast after a twenty-four-hour exposure, while Watson,[5] comparing the action of the double iodide with that of iodin solutions, found that the former was far superior in its killing action on Staphylococci, Bacillus coli and even the sporulating Bacillus subtilis.

With a view to gaining additional and more exact information concerning the germicidal action of potassium mercuric iodide the

[8] Pathogenic Microörganisms, 6th ed., Philadelphia, Lea & Febiger, 1917, p. 668.

author, with the assistance of Dean, has carried out the following experiments:

1. *Technic.* A series of tubes containing the water solutions of potassium mercuric iodide of varying concentrations were inoculated with 0.1 c.c. of actively growing broth cultures of (1) Staphylococcus albus, (2) Bacillus coli communis and (3) Bacillus subtilis (containing free spores). At the end of the indicated exposures a 2 mm. loopful of the mixture was transferred to nutrient broth and the tubes incubated at 37.5°. Growth was further controlled by plating these incubated broth cultures.

2. *Results:*

TABLE I.—STAPHYLOCOCCUS ALBUS.

Dilution: K_2HgI_4.	Time of exposure (minutes). 3	5	10	20	30	60
1–5000	X	0	0	0	0	0
1–4000	0	0	0	0	0	0
1–3000	0	0	0	0	0	0
1–2000	0	0	0	0	0	0
1–1000	0	0	0	0	0	0
1– 500	0	0	0	0	0	0
1– 100	0	0	0	0	0	0
Broth control	X	X	X	X	X	X

X = Growth.
O = No growth

TABLE II.—STAPHYLOCOCCUS ALBUS (CONTINUED).

Dilution: K_2HgI_4.	Time of exposure (hours). ½	1	2	3	6	12	24
1–100,000	X	X	0	0	0	0	0
1– 90,000	X	X	0	0	0	0	0
1– 80,000	X	X	0	0	0	0	0
1– 70,000	X	X	0	0	0	0	0
1– 60,000	X	X	0	0	0	0	0
1– 50,000	X	X	0	0	0	0	0
1– 40,000	X	X	0	0	0	0	0
1– 30,000	X	X	0	0	0	0	0
1– 20,000	X	X	0	0	0	0	0
1– 10,000	X	X	0	0	0	0	0
Broth control	X	X	X	X	X	X	X

TABLE III.—BACILLUS COLI COMMUNIS.

Dilution: K_2HgI_4.	Time of exposure (minutes). 1	2	3	5	10	20	30	60
1–5000	X	X	X	X	X	X	X	0
1–4000	X	X	X	X	X	X	X	0
1–3000	X	X	X	X	X	0	0	0
1–2000	X	X	X	X	0	0	0	0
1–1000	X	X	0	0	0	0	0	0
1– 500	X	0	0	0	0	0	0	0
1– 100	0	0	0	0	0	0	0	0
Broth control	X	X	X	X	X	X	X	X

TABLE IV.—BACILLUS COLI COMMUNIS (CONTINUED).

Dilution: K_2HgI_4.	Time of exposure (hours). ½	1	2	3	4	5	6	12	24
1–100,000	X	X	X	X	X	X	X	X	X
1– 90,000	X	X	X	X	X	X	X	X	0
1– 80,000	X	X	X	X	X	X	X	X	0
1– 70,000	X	X	X	X	X	X	X	X	0
1– 60,000	X	X	X	X	X	X	X	X	0
1– 50,000	X	X	X	X	X	X	X	X	0
1– 40,000	X	X	X	X	X	X	X	0	0
1– 30,000	X	X	X	X	X	X	0	0	0
1– 20,000	X	X	X	0	0	0	0	0	0
1– 10,000	X	X	0	0	0	0	0	0	0
1– 5,000	X	0	0	0	0	0	0	0	0
1– 1,000	0	0	0	0	0	0	0	0	0
Broth control	X	X	X	X	X	X	X	X	X

TABLE V.—BACILLUS SUBTILIS.

Dilution: K_2HgI_4.	Time of exposure (minutes). 3	5	10	20	30	40	50	60
1–5000	X	X	X	X	X	X	X	X
	(X)	(X)	(X)	(X)	(X)	(X)	(X)	(X)
1–4000	X	X	X	X	X	X	X	X
1–3000	X	X	X	X	X	X	X	X
1–2000	X	X	X	X	X	X	X	X
1–1000	X	X	X	X	X	X	X	X
	(X)	(X)	(X)	(X)	(X)	(X)	(X)	(X)
1– 500	X	X	X	X	X	X	X	0
	(X)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
1– 100	X	0	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Broth control	X	X	X	X	X	X	X	X

X = Growth, 0 = No growth } 1st series.

(X) = Growth, (0) = No growth } 2d series.

TABLE VI.—BACILLUS SUBTILIS (CONTINUED).

Dilution: K_2HgI_4.	Time of exposure (hours.) ½	1	2	3	6	12	24
1–100,000	X	X	X	X	X	X	X
1– 90,000	..	..	..	..	..	..	X
1– 80,000	..	..	..	..	..	..	X
1– 70,000	..	..	..	..	..	..	X
1– 60,000	..	..	..	..	..	..	X
1– 50,000	X	X	X	X	X	X	X
1– 40,000	X	X	X	X	X	X	X
1– 30,000	X	X	X	X	X	X	X
1– 20,000	X	X	X	X	X	X	X
1– 10,000	X	X	X	X	X	X	0
	(X)	(X)	..	..	(X)		
1– 5,000	X	X	X	X	X	0	0
	(X)	(X)	..	..	(X)		
1– 1,000	X	X	X	X	0	0	0
	(X)	(X)					
Broth control	X	X	X	X	X	X	X

The above tables are self-explanatory. The results prove that potassium mercuric iodide possesses a remarkably high germicidal

efficiency. The fact that a pus-producing organism such as the Staphylococcus is killed in five minutes by a 1 to 5000 solution shows that this double iodide may be effectively used in dilutions which are incapable of producing irritation to the most sensitive tissues or of causing poisoning under the usual therapeutic conditions. In Tables V and VI the rapid action of 1 to 100 and even to 500 solutions on a sporulating culture of Bacillus subtilis may be taken as an indication of the action of this double salt on pathogenic sporulating bacilli such as the organisms of tetanus, anthrax, gas gangrene and malignant edema.

In order to determine to what extent the presence of organic matter, serum proteins especially, might interfere with or diminish the bactericidal action of potassium mercuric iodide, the following experiment was carried out:

I. *Technic.* To tubes containing 2 c.c. of the different dilutions of the germicide was added sufficient human serum to give an actual coagulable protein content of 0.5 per cent. (determined by gravimetric method). The solution remained perfectly clear, but solidified on boiling. The tubes were allowed to stand twenty-four hours to allow any possible reaction between the double iodide and the albumin to take place. The tubes were then inoculated with 0.1 c.c. of an actively growing broth culture of Staphylococcus albus freshly isolated from a human infection. After the stated period of exposure, subcultures, using one 2 mm. loopful, were made in liquefied nutrient agar at 40° and then plated. After incubation the plates showed either no growth or a heavy growth, except in the cases of the twelve-hour exposure, where the colonies were few.

II. *Results.*

TABLE VII.

Dilution, HgI_2.	Staphylococcus, strain A. Time.						Staphylococcus, strain B. Time.						Staphylococcus, strain B, with human serum. Time.					
	3″	5″	10″	30″	1′	6′	12′	3″	5″	10″	30″	1′	6′	12′	3″	5″	10″	30″	1′	6′	12′
1– 500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1– 1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1– 5,000	X	0	0	0	0	0	0	0	0	0	0	0	0	0	X	X	X	X	0	0	0
1– 10,000	X	X	X	X	0	2	0	X	X	X	X	X	0	0	X	X	X	X	X	0	0
1– 50,000	X	X	X	X	X	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1–100,000	X	X	X	X	X	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X

The results show that organic matter in the form of human serum albumin in a concentration of 0.5 per cent. has no appreciable effect on the germicidal action of 1 to 500 and 1 to 1000 solutions of potassium mercuric iodide. As might be expected with the weaker concentration of germicide, protein delays their bacterial action,

but this diminution is relatively slight when compared with McClintic's reports[9] on the germicidal powers of phenol and some commercial disinfectants in the presence of organic matter.

DISCUSSION. The experiments submitted show that potassium mercuric iodide is a powerful germicide exhibiting marked bactericidal efficiency in high dilutions. Organic matter diminishes its potency to a relatively slight degree. These facts, taken in consideration with its great solubility, its freedom from irritant action and its comparatively low toxicity in the solutions efficacious for germicidal purposes, would seem to recommend this double salt of the iodides of potassium and mercury as the most desirable of the inorganic germicides.

[9] Hygienic Lab. Bull., April, 1912, lxxxii, 37 *et seq.*

ERRATA.

The Editor assumes responsibility for the unfortunate errors that occurred in the article entitled, "The Oculopupillary Fibers of the Sympathetic System: Division of the First Thoracic Root in Man," by William G. Spiller, M.D., which was published in the issue of this Journal for March, 1920, p. 325. Attention is called to the following corrections:

On page 326, line 39, a comma should be inserted after the word tactile.

On page 331, line 17, "Mmes. Dejerine and Klumpke" should be corrected to read "Madam Dejerine Klumpke."

On the same page, line 41, "She" should be changed to "He."

On line 44 of the same page, "Mmes. Dejerine and Klumpke" should again be corrected to "Madam Dejerine Klumpke."

On page 336, line 21, "her" should be changed to "his," and on line 24 of the same page, "she" should be changed to "he."